Table 5a

Maximum Permissible Exposure (MPE) for Small-Source Ocular Exposure to a Laser Beam †

Wavelength (μm)	Exposure Duration, t (s)	MPE ($J \cdot cm^{-2}$)	MPE ($W \cdot cm^{-2}$)	Notes
Ultraviolet				
0.180 to 0.302	10^{-9} to 3×10^{4}	3×10^{-3}		or $0.56\ t^{0.25}$ whichever is lower. (See Tables 8 and 9 for limiting apertures)
0.303	10^{-9} to 3×10^{4}	4×10^{-3}		
0.304	10^{-9} to 3×10^{4}	6×10^{-3}		
0.305	10^{-9} to 3×10^{4}	10×10^{-3}		
0.306	10^{-9} to 3×10^{4}	16×10^{-3}		
0.307	10^{-9} to 3×10^{4}	25×10^{-3}		
0.308	10^{-9} to 3×10^{4}	40×10^{-3}		
0.309	10^{-9} to 3×10^{4}	63×10^{-3}		
0.310	10^{-9} to 3×10^{4}	0.1		
0.311	10^{-9} to 3×10^{4}	0.16		
0.312	10^{-9} to 3×10^{4}	0.25		
0.313	10^{-9} to 3×10^{4}	0.40		
0.314	10^{-9} to 3×10^{4}	0.63		
0.315 to 0.400	10^{-9} to 10	$0.56\ t^{0.25}$		
0.315 to 0.400	10 to 3×10^{4}	1.0		
Visible and Near Infrared				
0.400 to 0.700	10^{-13} to 10^{-11}	1.5×10^{-8}		(See Tables 8 and 9 for limiting apertures) For multiple pulses apply correction factor C_p given in Table 6.
0.400 to 0.700	10^{-11} to 10^{-9}	$2.7\ t^{0.75}$		
0.400 to 0.700	10^{-9} to 18×10^{-6}	5.0×10^{-7}		
0.400 to 0.700	18×10^{-6} to 10	$1.8\ t^{0.75} \times 10^{-3}$		
0.400 to 0.450	10 to 100	1×10^{-2}		
0.450 to 0.500	10 to T_1		1×10^{-3}	
0.450 to 0.500	T_1 to 100	$C_B \times 10^{-2}$		
0.400 to 0.500	100 to 3×10^{4}		$C_B \times 10^{-4}$	
0.500 to 0.700	10 to 3×10^{4}		1×10^{-3}	
0.700 to 1.050	10^{-13} to 10^{-11}	$1.5\ C_A \times 10^{-8}$		
0.700 to 1.050	10^{-11} to 10^{-9}	$2.7\ C_A\ t^{0.75}$		
0.700 to 1.050	10^{-9} to 18×10^{-6}	$5.0\ C_A \times 10^{-7}$		
0.700 to 1.050	18×10^{-6} to 10	$1.8\ C_A\ t^{0.75} \times 10^{-3}$		
0.700 to 1.050	10 to 3×10^{4}		$C_A \times 10^{-3}$	
1.050 to 1.400	10^{-13} to 10^{-11}	$1.5\ C_C \times 10^{-7}$		
1.050 to 1.400	10^{-11} to 10^{-9}	$27.0\ C_C\ t^{0.75}$		
1.050 to 1.400	10^{-9} to 50×10^{-6}	$5.0\ C_C \times 10^{-6}$		
1.050 to 1.400	50×10^{-6} to 10	$9.0\ C_C\ t^{0.75} \times 10^{-3}$		
1.050 to 1.400	10 to 3×10^{4}		$5.0\ C_C \times 10^{-3}$	
Far Infrared				
1.400 to 1.500	10^{-9} to 10^{-3}	0.1		For multiple pulses apply correction factor C_p given in Table 6 (See Tables 8 and 9 for limiting apertures)
1.400 to 1.500	10^{-3} to 10	$0.56\ t^{0.25}$		
1.400 to 1.500	10 to 3×10^{4}		0.1	
1.500 to 1.800	10^{-9} to 10	1.0		
1.500 to 1.800	10 to 3×10^{4}		0.1	
1.800 to 2.600	10^{-9} to 10^{-3}	0.1		
1.800 to 2.600	10^{-3} to 10	$0.56\ t^{0.25}$		
1.800 to 2.600	10 to 3×10^{4}		0.1	
2.600 to 10^{3}	10^{-9} to 10^{-7}	1×10^{-2}		
2.600 to 10^{3}	10^{-7} to 10	$0.56\ t^{0.25}$		
2.600 to 10^{3}	10 to 3×10^{4}		0.1	

† See Table 6 and Figures 8 and 9 for correction factors C_A, C_B and time T_1. For exposure durations greater than 10 seconds and extended sources in the retinal hazard region (0.400 to 1.4 μm), see Table 5b.

Notes:
1. For repeated (pulsed) exposures, see Section 8.2.3.
2. The wavelength region λ_1 to λ_2 means $\lambda_1 \leq \lambda < \lambda_2$, e.g., 0.180 to 0.302 μm means $0.180 \leq \lambda < 0.302$ μm.
3. Dual Limit Application: In the Dual Limit Wavelength Region (0.400 to 0.600 μm), the listed MPE is the lower value of the photochemical and thermal MPEs as determined by T_1.

APPENDIX 1

Table 5b
Maximum Permissible Exposure (MPE) for Extended-Source Ocular Exposure to a Laser Beam for Long Exposure Durations†

Wavelength (μm)	Exposure Duration, t (s)	MPE ($J \cdot cm^{-2}$) except as noted	MPE ($W \cdot cm^{-2}$) except as noted	Notes
Visible				
0.400 to 0.700	10^{-13} to 10^{-11}	$1.5\ C_E \times 10^{-8}$		(See Tables 8 and 9 for limiting apertures)
0.400 to 0.700	10^{-11} to 10^{-9}	$2.7\ C_E\ t^{0.75}$		
0.400 to 0.700	10^{-9} to 18×10^{-6}	$5.0\ C_E \times 10^{-7}$		
0.400 to 0.700	18×10^{-6} to 0.7	$1.8\ C_E\ t^{0.75} \times 10^{-3}$		
	Dual Limits for 400 - 600 nm visible laser exposure for $t > 0.7$ s			
Photochemical				
	For $\alpha \leq 11$ mrad, the MPE is expressed as irradiance and radiant exposure*			
0.400 to 0.600	0.7 to 100	$C_B \times 10^{-2}$		(See Tables 8 and 9 for limiting apertures)
0.400 to 0.600	100 to 3×10^4		$C_B \times 10^{-4}$	
	For $\alpha > 11$ mrad, the MPE is expressed as radiance and integrated radiance*			
0.400 to 0.600	0.7 to 1×10^4	$100\ C_B$ J·cm^{-2}·sr^{-1}		(See Table 8 for limiting cone angle γ)
0.400 to 0.600	1×10^4 to 3×10^4		$C_B \times 10^{-2}$ W·cm^{-2}·sr^{-1}	
	and			
Thermal				
0.400 to 0.700	0.7 to T_2	$1.8\ C_E\ t^{0.75} \times 10^{-3}$		
0.400 to 0.700	T_2 to 3×10^4		$1.8\ C_E\ T_2^{-0.25} \times 10^{-3}$	
Near Infrared				
0.700 to 1.050	10^{-13} to 10^{-11}	$1.5\ C_A\ C_E \times 10^{-8}$		(See Tables 8 and 9 for limiting apertures)
0.700 to 1.050	10^{-11} to 10^{-9}	$2.7\ C_A\ C_E\ t^{0.75}$		
0.700 to 1.050	10^{-9} to 18×10^{-6}	$5.0\ C_A\ C_E \times 10^{-7}$		
0.700 to 1.050	18×10^{-6} to T_2	$1.8\ C_A\ C_E\ t^{0.75} \times 10^{-3}$		
0.700 to 1.050	T_2 to 3×10^4		$1.8\ C_A\ C_E\ T_2^{-0.25} \times 10^{-3}$	
1.050 to 1.400	10^{-13} to 10^{-11}	$1.5\ C_C\ C_E \times 10^{-7}$		
1.050 to 1.400	10^{-11} to 10^{-9}	$27.0\ C_C\ C_E\ t^{0.75}$		
1.050 to 1.400	10^{-9} to 50×10^{-6}	$5.0\ C_C\ C_E \times 10^{-6}$		
1.050 to 1.400	50×10^{-6} to T_2	$9.0\ C_C\ C_E\ t^{0.75} \times 10^{-3}$		
1.050 to 1.400	T_2 to 3×10^4		$9.0\ C_C\ C_E\ T_2^{-0.25} \times 10^{-3}$	

†See Table 6 and Figures 8, 9 and 11 for correction factors C_A, C_B, C_C, C_E, C_P, and time T_2.

*For sources subtending an angle greater than 11 mrad, the limit may also be expressed as an integrated radiance $L_p = 100\ C_B$ J·cm^{-2}·sr^{-1} for $0.7\ s \leq t < 10^4$ s and $L_e = C_B \times 10^{-2}$ W·cm^{-2}·sr^{-1} for $t \geq 10^4$ s as measured through a limiting cone angle γ. These correspond to values of J·cm^{-2} for $10\ s \leq t < 100$ s and W·cm^{-2} for $t \geq 100$ s as measured through a limiting cone angle γ.

$\gamma = 11$ mrad for $0.7\ s \leq t < 100$ s,

$\gamma = 1.1 \times t^{0.5}$ mrad for $100\ s \leq t < 10^4$ s

$\gamma = 110$ mrad for $10^4\ s \leq t < 3 \times 10^4$ s

See Figure 3 for γ and Appendix B7.2 for examples.

Notes:
1. For repeated (pulsed) exposures, see Section 8.2.3.
2. The wavelength region λ_1 to λ_2 means $\lambda_1 \leq \lambda < \lambda_2$, e.g., 1.180 to 1.302 μm means $1.180 \leq \lambda < 1.302$ μm.
3. Dual Limit Application: In the Dual Limit wavelength region (0.400 to 0.600 μm), the exposure limit is the lower value of the determined photochemical and thermal exposure limit.

APPENDIX 2